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Defense Nuclear Nonproliferation Research & Development Program

Detection of Prompt Photofission Neutrons from ^{238}U with a ^{4}He Scintillation Detector

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Abstract

The use of photon active interrogation for detection of special nuclear material has held significant theoretical promise, as the interrogating source particles, photons, are fundamentally different from one of the main signatures of SNM - neutrons produced in nuclear fission. However, neutrons produced by photonuclear reactions in the accelerator target, collimator, and in the environment, can obscure the fission neutron signal. These (gamma,n) neutrons could be discriminated from fission neutrons by their energy spectrum, but common detectors sensitive to the neutron spectrum, like PSD-capable organic scintillators, are typically crippled by the extremely intense photon environment characteristic of photon-based active interrogation. In contrast, novel high-pressure He-4-based scintillation detectors are well suited to this application, as they are similarly sensitive to the neutron spectrum, but their response to gamma rays is very limited in comparison to that of organic scintillators. In this work, a He-4 scintillation detector was evaluated for the photon active interrogation. The detector is shown to be capable of operating in intense gamma-ray environments, and capable of detecting photofission neutrons from U-238 when interrogated by a 9 MV linac bremsstrahlung source. These photofission neutrons could be easily discriminated from (gamma,n) neutrons based on their spectrum.

Goals, Objectives, and Deliverables

- This work represents a novel means to detect special nuclear materials which may be heavily shielded or self-attenuating.
- The method laid out in this work could conceivably be applied to a variety of applications in nuclear safeguards and security:
  - Verification of the contents of spent nuclear fuel casks for safeguards
  - Interdiction of illicit nuclear materials at border crossings

Results/Technical Challenges

- The ^{4}He detector was shown to be insensitive to gamma rays if a 275 keV energy deposition threshold is used
- The detector system was shown to be capable of discriminating between uranium photofission and lead (γ,n) neutrons with excellent separation (FOM > 9)

Planned Accomplishments

- Ultimately, it is desired for this active interrogation method to be optimized to allow confident detection of fissionable materials on timescales suitable for the nuclear safeguards and security application (seconds to minutes). Statistical discrimination methods are being investigated to reach this goal
- A journal article with our method and results to be submitted this year

Notes

Research Team

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